

# Informational Leaflet 73

OBSERVATION OF BRISTOL BAY SEISMIC OPERATION,

AUGUST 2 - AUGUST 10, 1965

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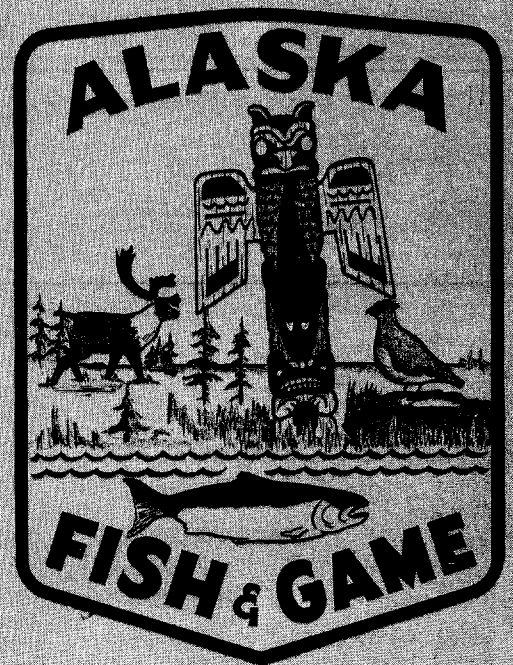
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By

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I. INTRODUCTION

The first offshore seismic operation in Bristol Bay was begun during the period August 2 - August 10, 1965, by Geophysical Services for its client, the Continental Oil Co. A permit was issued by the Alaska Department of Fish and Game to Geophysical Services, Inc. (G.S.I.) to conduct seismic work in Bristol Bay from Cape Seniavin to Cape Peirce. Two employees of the Alaska Department of Fish and Game observed the operations in order to insure protection of existing fish stocks.

II. PROCEDURES OF THE SEISMIC OPERATION

A. Geophysical Services, Inc.

Detonations of 50 pounds of nitromon explosive were made every 1,200 feet along a line drawn from Cape Seniavin on the Alaskan Peninsula to Cape Peirce on the north side of Bristol Bay (Figure 1). Recordings were made of the reflected seismic waves produced in order to define underlying strata. Two vessels were used by G.S.I. in the seismic operation in addition to one vessel used by A.D.F. & G. to observe fish mortalities. The motor vessel "SITKIN", a 165' converted mine hunter, was the command boat in the operation (Figures 2 and 3). The procedure followed was for the M/V SITKIN to accurately pin point its position along the Cape Seniavin-Cape Peirce line by the use of "shoran" navigational equipment. As the SITKIN proceeded along the line a signal was given to the M/V GREBE, the shooting boat, approximately 40 seconds before a shot was to be made. The location of each recording position on the line, called a shot point, was determined precisely by "shoran". After the 40 second warning the shooting crew, consisting of 6 men, prepared the 50 pound charge

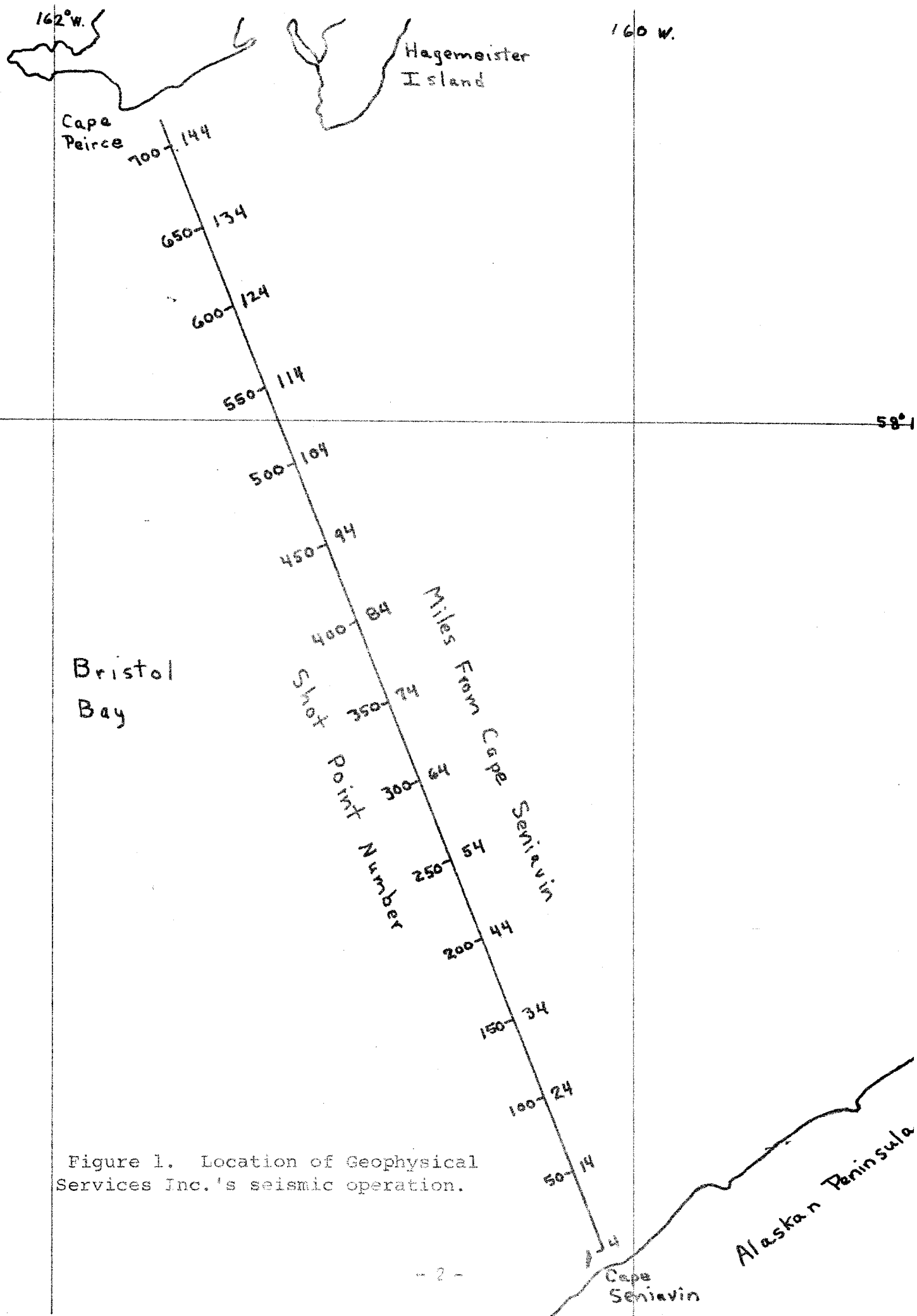


Figure 1. Location of Geophysical Services Inc.'s seismic operation.

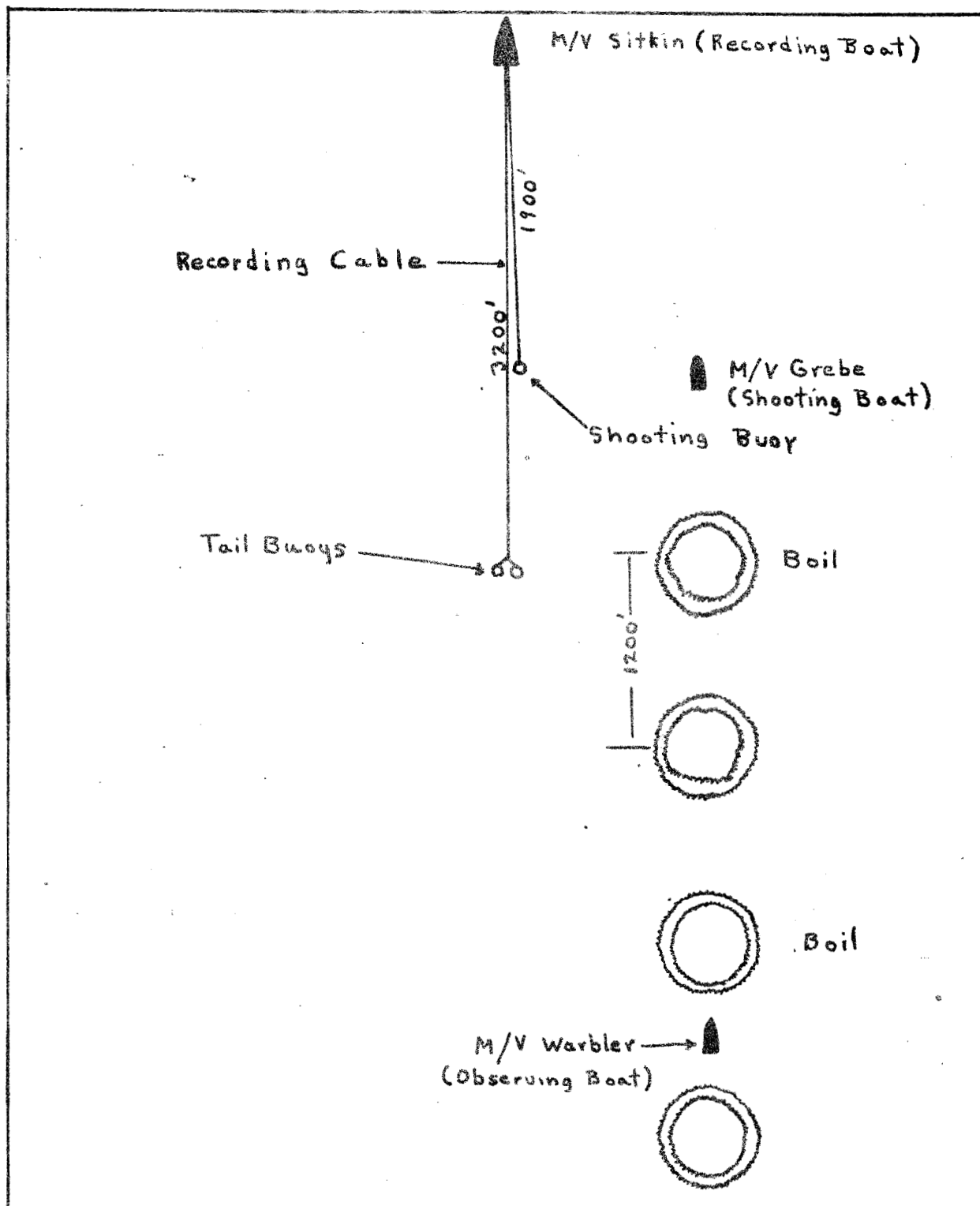


Figure 2. Schematic diagram of the G.S.I. seismic operation, Aug. 2 - 10, 1965. Top view.

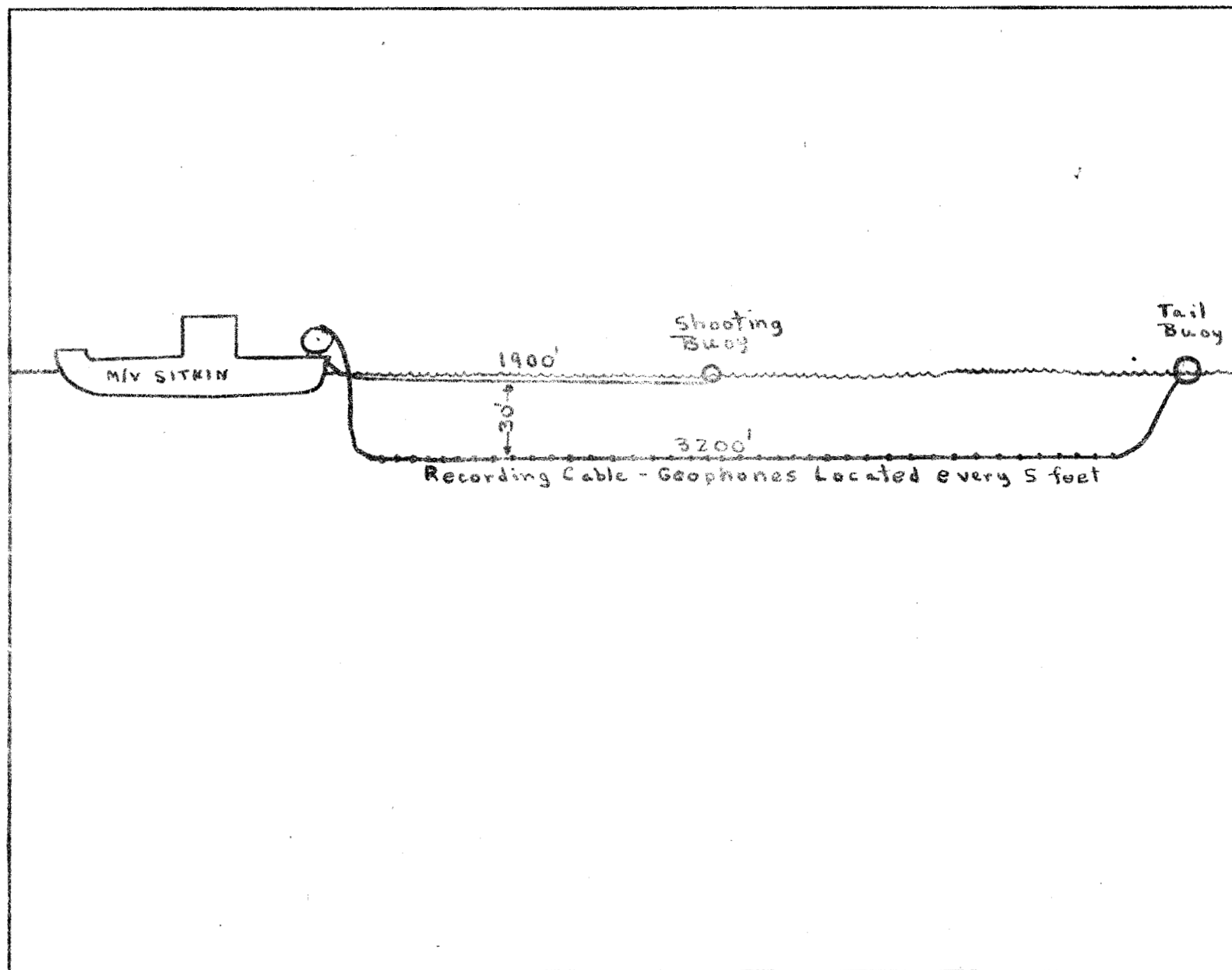


Figure 3. Schematic diagram of the G.S.I. seismic program, Aug. 2 -10, 1965.  
(Side view)

(Nitromon) for detonation. This was accomplished by attaching a booster and an electric detonating cap to the charge which in turn was suspended by 6 feet of manila string to an inflated pastic bag. An electrical cable was attached to the electric detonating cap of the charge. The charge was then thrown overboard and the cable fed out until it was a safe distance from the shooting boat. When this was accomplished, the two safety switches on the shooting boat were closed and the SITKIN, the recording boat, was notified by special radio communications that the charge was clear of the boat. When the SITKIN reached the exact position of the shot point, a F.M. signal was sent to the shooting boat which automatically detonated the charge. Simultaneously, the recording equipment was activated. After the charge had been detonated and the seismic waves recorded, the operation was repeated for the next shot point.

Although "shoran" was used on the south side of Bristol Bay, it was not adequate for distances greater than 60 or 70 miles. At distances greater than this, the "Raydist" navigational system was used.

#### B. Alaska Department of Fish and Game

The M/V WARBLER, a converted 110 foot submarine chaser, was used by the Department of Fish and Game to observe the boils caused by the seismic explosions. This vessel was used exclusively by the Fish and Game observers (Figure 2).

The procedure followed was to inspect and count each boil for stunned or dead fish and for other forms of life. Instead of inspecting each boil as it was made, it was the practice to follow at least 3 or 4 boils behind the shooting boat. In this way adequate time was allowed for affected fish to rise to the surface. Several times the observer boat followed only 1 or 2 boils behind the shooting boat. During these times fish could be seen rising through the water toward the surface. A representative collection of fish was made from Cape Seniavin to Cape Peirce in order to identify the species present. The boils caused by the detonations were readily visible and consisted of a becalmed area 300-400 feet in diameter encircled by a ring of foam. These boils lasted for a considerable length of time, providing the sea was not heavy. In a heavy sea the wave action dissipated the boils quickly. The majority of dead or stunned fish was observed near the edge of the boil near the ring of foam. Lesser numbers of fish were observed in the middle of the boil and outside the boil area. When wind conditions were unfavorable, considerable numbers of fish drifted away from the boil and could be seen several hundred yards away.

The appearance of the fish in the boil also varied according to the species of fish present. Cod, herring, and smelt floated horizontally in the water while the immature red salmon usually floated vertically, the head pointed toward the surface.

Communication between the recording boat, shooting boat, and observing boat was by a citizens band radio. The use of the ships' radios was forbidden during a shooting run because of the possibility of an accidental detonation. Since shooting was conducting during all daylight hours, radio communication with the area A.D.F. & G. office was on an irregular basis.

On occasion, electrical troubles caused the charges to fail to detonate. Since the charges are suspended only 6 feet beneath the surface, a hindrance to navigation was produced. The captain of the observer boat usually sank the charges by breaking the plastic bag with rifle fire.

### III. FISH MORTALITIES

#### A. Numbers of Individual Species

Six species of fish were observed during the seismic operation. They were Pacific cod, Gadus macrocephalus, red salmon, Oncorhynchus nerka, Pacific herring, Clupea pallasii, arctic or toothed smelt, Osmerus dentex, saffron cod, Eleginus gracilis, and candlefish, species unknown. The numbers of individual species killed were:

Pacific cod .....	7,250
arctic smelt .....	2,469
Pacific herring.....	2,022
red salmon .....	260
candlefish.....	200
saffron cod .....	133
unidentified species .....	16

It should be noted that these figures are undoubtedly underestimates of the true kill. Since it was not possible to fully cover a boil because of a lack of time, fish which were outside the boil area might not be counted. Fish which sank would also not be included in the kill.

Besides the fish enumerated above, many larvae (1-1/4") were seen on the south side of Bristol Bay although collecting equipment was not available to catch them. They were probably Pacific cod larvae.

Other forms of life killed by the seismic explosions were numerous jellyfish and several unidentified species of ducks.

#### B. Distribution of Species

The distribution of fish along the line from Cape Seniavin to Cape



Peirce was conspicuously uneven (Table 1). The Pacific cod, the most abundant species, was concentrated on the southern side of Bristol Bay (Figure 4). In the middle and northern portions of the bay the Pacific cod were scarce. It was also observed that Pacific cod found closer to the southern shore were generally smaller (less than 10") while those farther out were considerably larger (greater than 10").

The immature red salmon were similarly found on the south side of Bristol Bay although in a slightly tighter band (Figures 5 and 6). Unlike the Pacific cod, the red salmon were found not closer than 19 miles offshore from Cape Seniavin nor farther than 35 miles. The majority of red salmon were observed from 22 to 24 miles from Cape Seniavin.

Pacific herring, arctic smelt, and the saffron cod were found sympatrically in the northern portion of Bristol Bay from approximately 4 to 20 miles south of Cape Peirce (Figures 4 and 7).

Candlefish were found at only one location on the south side of Bristol Bay.

#### IV. ANALYSIS OF FISH SAMPLES

##### A. Age and Length of Red Salmon

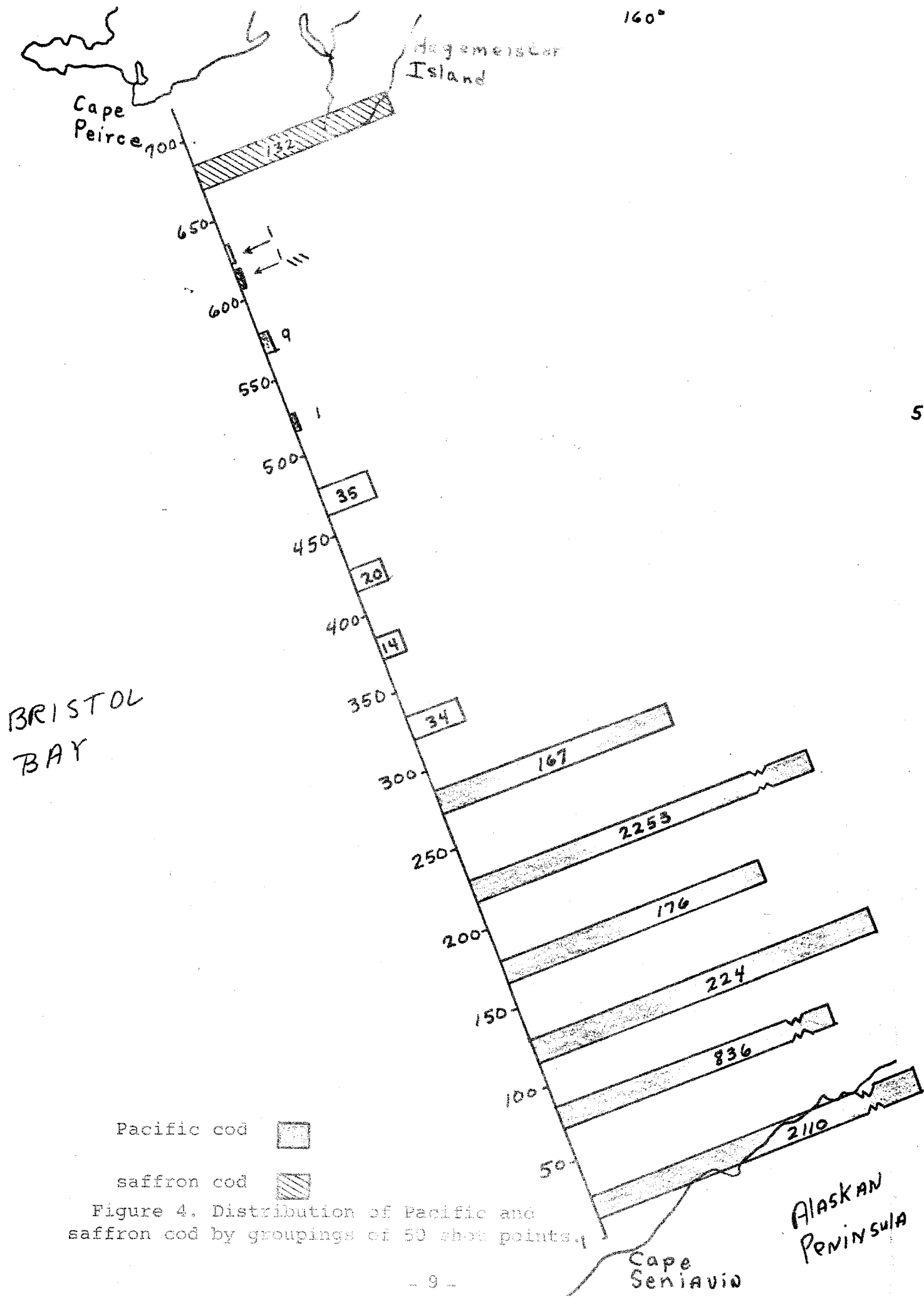
Eighteen immature red salmon were collected approximately 20 miles north of Cape Seniavin. The results of the analysis of these samples are presented in Table 2. Seventeen of the eighteen red salmon collected were 2-check freshwater fish having a mean length of 153.1 mm. The scales of these fish showed no freshwater plus growth past the second annulus indicating an early outmigration from the lakes. An average of 4.6 marine circuli was present on the scales of these fish. One fish showing only 1 freshwater check was observed. This fish measured 126 mm.

##### B. Condition of Fish

Samples of dead or stunned fish were collected from the boils to examine for internal and external damage. Two species of cod, the Pacific and saffron cod, were examined both internally and externally while the herring and smelt were examined only externally. The results of the examinations are shown in Table 3. In general, the gross internal damage to both species of cod was the hemorrhaging of the liver and kidney. External damage to the cods amounted to distended abdomens, hemorrhaged gills and flesh, and the stomach protruding

TABLE 1: DISTRIBUTION OF FISH IN BRISTOL BAY. FIVE SHOT POINTS  
EQUAL 1 MILE.

Location of fish kills- shot point number	Miles on the line from Cape Seniavin	Pacific Cod	Red Salmon	Pacific Herring	Arctic Smelt	Saffron Cod	Candle- fish
1-50	4-14	2,110	0	0	1	0	200
51-100	14-24	836	201	0	0	0	0
101-150	24-34	224	48	1	0	0	0
151-200	34-44	176	5	0	0	0	0
201-250	44-54	2,253	0	0	0	0	0
251-300	54-64	167	0	0	0	0	0
301-350	64-74	34	0	0	0	0	0
351-400	74-84	14	0	0	0	0	0
401-450	84-94	20	0	0	0	0	0
451-500	94-104	35	0	0	0	0	0
501-550	104-114	1	0	0	0	0	0
551-600	114-124	9	0	0	0	0	0
601-650	124-134	1	0	439	806	1	0
651-700	134-144	0	0	1,522	1,622	132	0
TOTALS		5,880	254	1,962	2,429	133	200



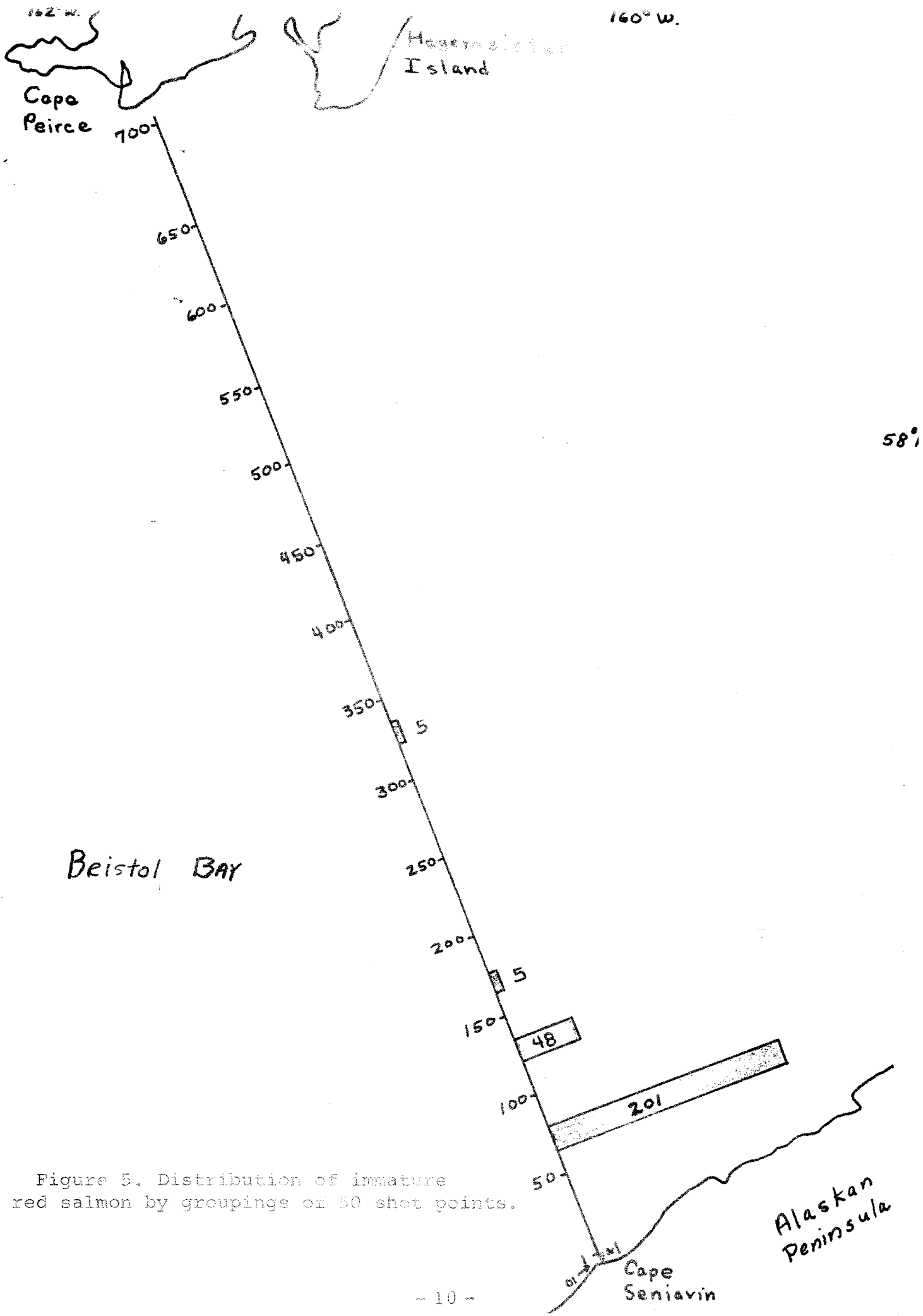


Figure 5. Distribution of immature red salmon by groupings of 50 shot points.

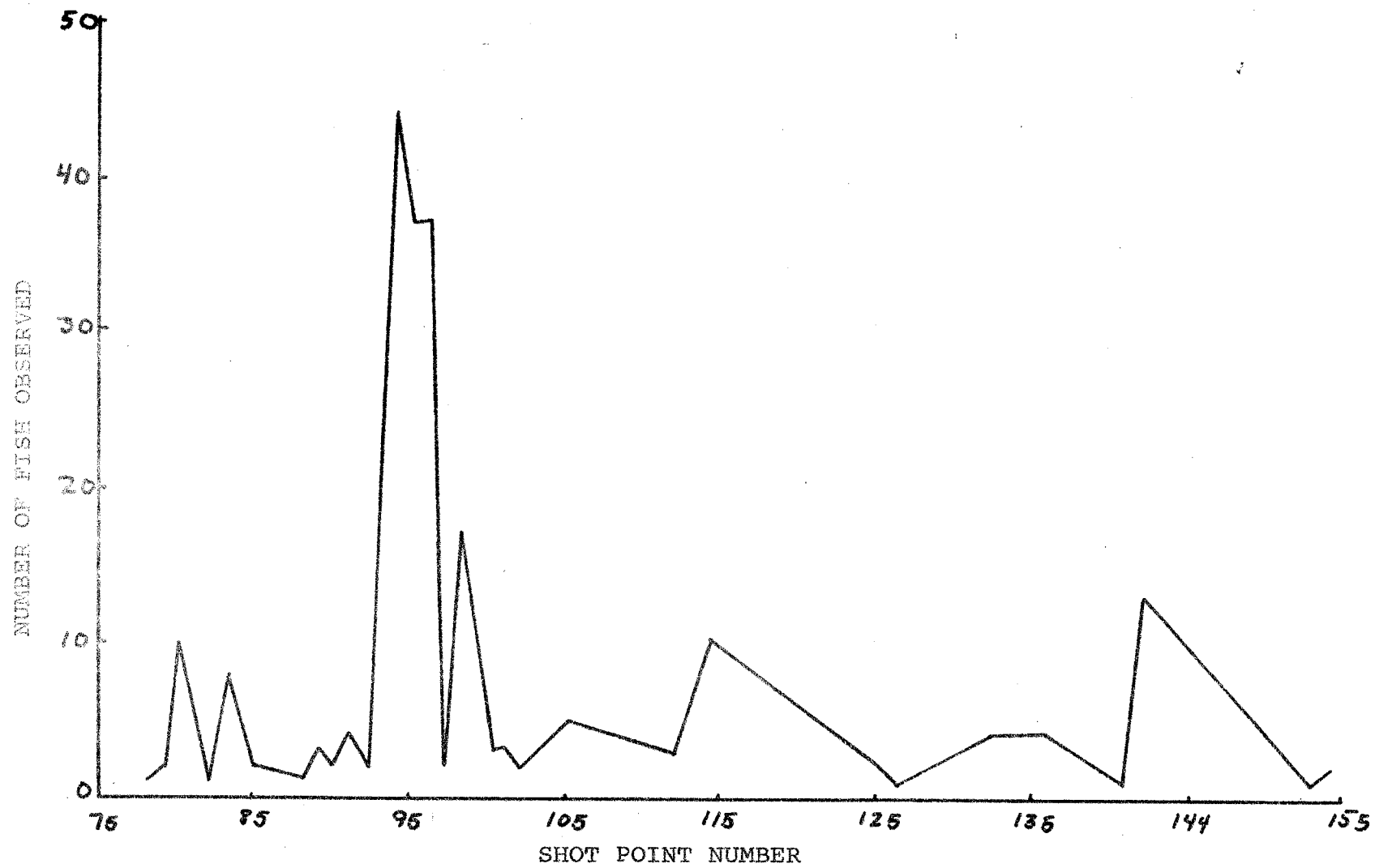


Figure 6. Distribution of immature red salmon between shot points #75-155.

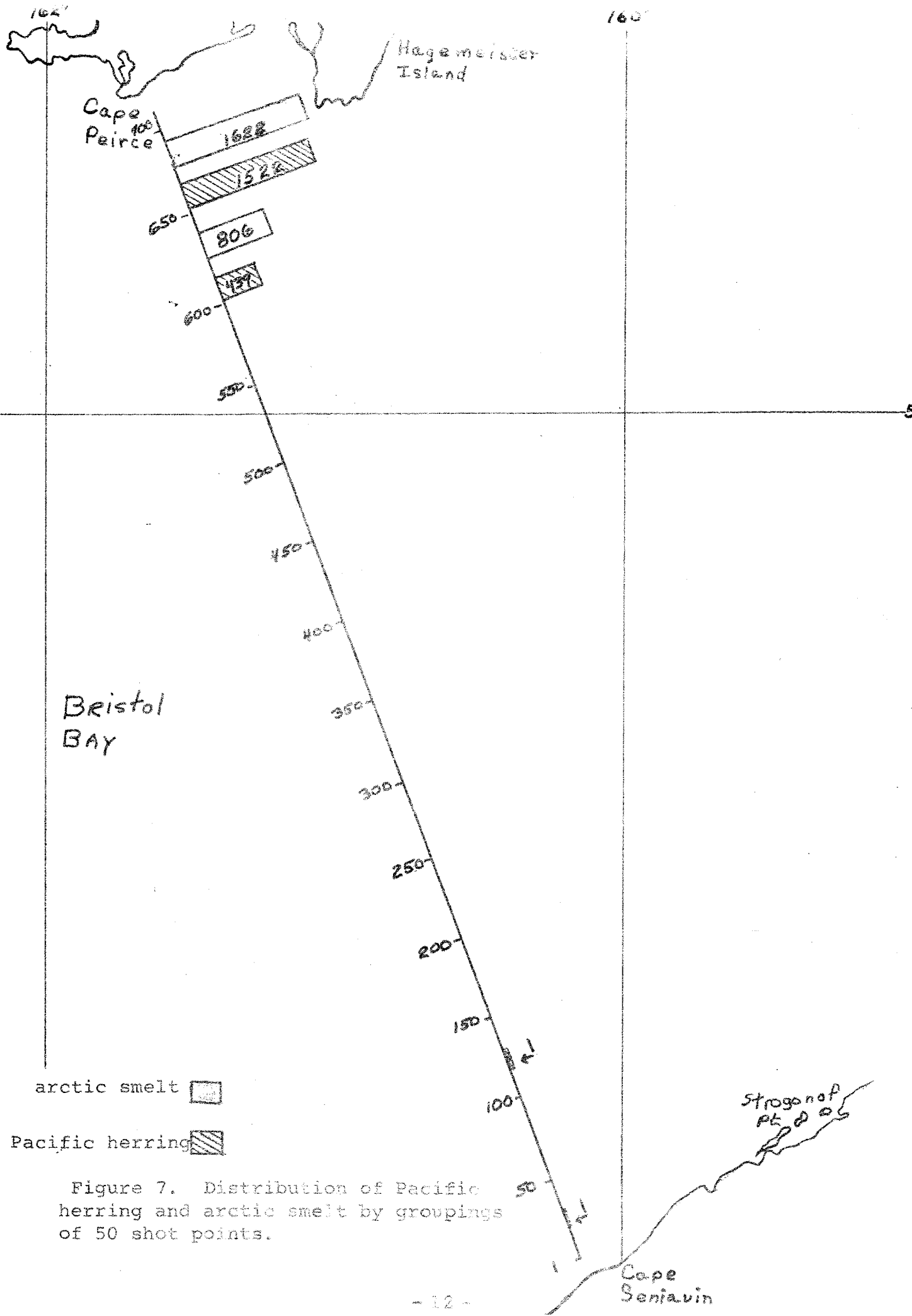


Figure 7. Distribution of Pacific herring and arctic smelt by groupings of 50 shot points.

TABLE 2. AGE AND LENGTH OF RED SALMON RECOVERED FROM  
THE 1965 BRISTOL BAY SEISMIC OPERATION.

Scale Number	TSTF Length- mm.	Number of Fresh- water annuli	Number of Marine Circuli
1	153	2	4
2	150	2	5
3	142	2	4
4	135	2	2
5	150	2	5
6	160	2	5
7	152	2	3
8	157	2	6
9	148	2	3
10	172	2	5
11	162	2	8
12	164	2	5
13	156	2	5
14	155	2	5
15	148	2	3
16	149	2	4
17	150	2	6
18	126	1	4

TABLE 3. EXAMINATION OF PACIFIC AND SAFFRON COD FOR INTERNAL AND EXTERNAL DAMAGE AND FOR STOMACH CONTENTS. FISH COLLECTED DURING 1965 BRISTOL BAY SEISMIC OPERATION.

Length in cm	Visible Injury to Fish	Stomach Contents
Pacific cod, <u>Gadus macrocephalus</u>		
<u>Shot Point #1-50</u>		
43	Liver and kidney hemorrhaged	----
43	Liver and kidney hemorrhaged	----
34	Kidney ruptured	----
38	Gill and kidney hemorrhaged, external hemorrhage of dorsal fin	----
44	Liver and kidney hemorrhaged	candlefish
45	Liver and kidney hemorrhaged	candlefish
35	Liver and kidney hemorrhaged	candlefish
34	Liver and kidney hemorrhaged	----
35	Liver and kidney hemorrhaged	----
37	Gills, liver, and kidney hemorrhaged	----
43	Liver and kidney hemorrhaged	----
34	Liver and kidney hemorrhaged	----
31	Gills, liver, and kidney hemorrhaged	----
36	External hemorrhaging of body, liver and kidney hemorrhaged	----
40	External hemorrhaging of body, liver and kidney hemorrhaged	----
48	Gills, liver and kidney hemorrhaged, external hemorrhaging of body	candlefish
34	Liver and kidney hemorrhaged	candlefish
31	External hemorrhaging of body, tumor in right gill, liver and kidney hemorrhaged	candlefish
30	Liver and kidney hemorrhaged, air bladder protruding out anus	----
35	Liver and kidney hemorrhaged	----
21	Kidney hemorrhaged, external hemorrhaging	----
26	Liver and kidney hemorrhaged, external hemorrhaging of body	----
21	External hemorrhaging, kidney hemorrhaged	----
29	Kidney hemorrhaged	----



Table 3. (Continued)

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29	Liver and kidney hemorrhaged	----
28	Liver and kidney hemorrhaged	----
28	Liver and kidney hemorrhaged	----

Shot Point #51-85

60	Liver and kidney hemorrhaged	herring
47	Kidney hemorrhaged, stomach protruding out mouth	----
51	Liver and kidney hemorrhaged, stomach protruding out mouth	----
49	Liver and kidney hemorrhaged, external hemorrhaging	small fish (sp?)
37	Liver and kidney hemorrhaged	candlefish
40	Liver and kidney hemorrhaged	----
42	Liver hemorrhaged, stomach protruding out mouth	candlefish
51	Liver and kidney hemorrhaged	candlefish
40	Gills and kidney hemorrhaged, external hemorrhaging	candlefish
36	Liver and kidney hemorrhaged, external hemorrhaging	candlefish
40	Liver and kidney hemorrhaged	----
42	Liver and kidney hemorrhaged	candlefish

Saffron cod, *Eleginus gracilis*Shot Point #651-673

29	Liver and kidney hemorrhaged	crustaceans
25	Liver hemorrhaged, kidney ruptured	----
26	Liver hemorrhaged, kidney ruptured	----
24	Liver hemorrhaged	crustaceans
25	Liver and kidney hemorrhaged	crustaceans
26	Liver hemorrhaged, kidney ruptured	crustaceans

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from the mouth. External examinations of the herring and smelt revealed hemorrhaged dorsal, pelvic, and anal fins.

One interesting anomaly noted among the Pacific cod was a large tumor above the gill chambers of three specimens.

#### C. Analysis of Pacific and Saffron Cod Stomachs

The stomachs of the cods collected were examined to ascertain whether any immature red salmon had been eaten. The presence of red salmon in the stomachs might yield some information on the distribution of immature red salmon in Bristol Bay. Thirty-nine Pacific cod and 6 saffron cod were examined. No red salmon were observed in any stomachs (Table 3). The stomachs of the Pacific cod contained mainly candlefish, small fish, or were empty. The saffron cod stomachs contained crustaceans.

#### V. CONCLUSION

The seismic operation conducted by Geophysical Services, Inc. during the period August 2-August 10 resulted in a kill of at least 12,350 fish. This figure is a substantial one. However, all of the fish with the exception of 260 immature red salmon are not presently of commercial importance in Bristol Bay. In the future, these species may be important.

Although substantial numbers of fish were killed in the seismic operation, valuable information was gained on the species present and their distribution. From the data gathered by the seismic operation it appears that considerable numbers of Pacific cod are found in the southern portion of Bristol Bay while considerable numbers of Pacific herring and arctic smelt are found in the northern portion. Immature red salmon were found in small numbers in a band from 19 to 35 miles north from Cape Seniavin. No red salmon were found in any stomach samples of either species of cod.

It should be remembered that the findings in this report are based on only one line across Bristol Bay during one time of the year. Also this report does not give an indication of the presence of bottom fishes since it is probable these species would be less likely to appear at the surface.

Examination of stunned or dead fish revealed hemorrhaging of the liver, kidneys, gills, flesh, and fins in addition to a bloating of the abdomen.

## VI. SUMMARY

- 1) Seismic exploration for oil was conducted for the first time in Bristol Bay during the period August 2 - August 10, 1965, by Geophysical Services, Inc. and its client, the Continental Oil Company.
- 2) Two observers from the Alaska Department of Fish and Game accompanied the G.S.I. operation in order to protect existing fish stocks in Bristol Bay.
- 3) A single line of approximately 700 detonations was made from Cape Seniavin on the Alaskan Peninsula to Cape Peirce on the northern side of Bristol Bay. Detonations of 50 pounds of Nitromon explosive were made every 1,200 feet between these points.
- 4) Three vessels were used by Geophysical Services, Inc. in the seismic operation: the recording and command vessel, the M/V SITKIN (165'); the shooting vessel, the M/V GREBE (110'); and the observing vessel, the M/V WARBLER (110').
- 5) 12,350 fish were accounted for in the seismic operation of which 7,250 were Pacific cod, Gadus macrocephalus, 2,469 were arctic smelt, Osmerus dentex, 2,022 were Pacific herring, Clupea pallasii, 260 were red salmon, Oncorhynchus nerka, 200 were candlefish, species unknown, 133 were saffron cod, Eleginus gracilis, and 16 were of unidentified species. In summary, the authors felt that excessive numbers of commercially important species were not destroyed.
- 6) An uneven distribution of fishes were observed on the line between Cape Seniavin and Cape Peirce. The southern portion of the bay yielded predominantly Pacific cod. Red salmon were also found on the south side of the bay but in a tighter band running from 19 to 35 miles from Cape Seniavin. The middle portion of Bristol Bay yielded very small numbers of Pacific cod. The northern portion yielded Pacific herring, arctic smelt, and saffron cod.
- 7) Samples of immature red salmon revealed them to be principally 2-check freshwater fish with a mean length of 153.1 mm.
- 8) Examination of stunned or dead Pacific cod and saffron cod revealed external hemorrhaging, hemorrhaging of the liver and kidneys, and distension of the abdomen. Hemorrhaging of the fins was observed in the Pacific herring and arctic smelt.
- 9) Stomach samples of Pacific cod contained primarily candlefish while the saffron cod were feeding primarily on crustaceans.

## VII. RECOMMENDATIONS

- 1) In conducting a seismic program in Bristol Bay, the observer vessel should be equipped with at least a 150 watt ship-to-shore radio in order to maintain communications with the area office.
- 2) A qualified Simrad observer should be furnished to insure that seismic operations will not be conducted where large quantities of fish are obviously present.
- 3) The observer vessel should not be requested to sink charges which have misfired.

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